



Three newly reported escaped non-native *Costus* L. species (Costaceae) in Java, Indonesia

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Abstract. *Costus* L. is the most species-rich genus in Costaceae and is mainly distributed in the Neotropics and tropical Africa. Five *Costus* species have been introduced to Java, Indonesia, for ornamental purposes. During our botanical expeditions in Java from January to May 2023, we discovered three previously unreported species of *Costus* that occur spontaneously in the wild: *C. phyllocephalus* K.Schum., *C. spicatus* (Jacq.) Sw., and *C. villosissimus* Jacq. Their spontaneous populations have been found on roadsides and abandoned areas in West Java.

Key words. Alien plant, introduced, Malesia, spiral ginger, Zingiberales

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INTRODUCTION

The genus *Costus* L. (Costaceae) consists of 99 species and is distributed worldwide, throughout tropical to subtropical regions, with a particular concentration in the Neotropics and Tropical Africa (Maas 1979; Wu and Larsen 2000; Specht 2006; Salzman et al. 2015; POWO 2024). The genus consists of rhizomatous herbs or occasionally epiphytes with a monostichous leaf arrangement and without axillary branches. Most of the species have terminal inflorescences, whereas in some epiphytic species such as *C. talbotii* Ridl. and *C. lateriflorus* Baker, the inflorescences are laterally developed. In addition to this, the labellum of Costaceae has a tubular shape (Specht and Stevenson 2006; Salzman et al. 2015).

According to Backer and Bakhuizen van den Brink (1968), four species of *Costus* were known in Java, Indonesia: *C. malortieanus* Wendl. (= *Costus elegans* Veitch ex J.Dix), *C. globosus* Blume (= *Parahellenia globosa* (Blume) N.H.Xia, Juan Chen & S.Jin Zeng), *C. igneus* N.E.Br. (= *Chamaecostus cuspidatus* (Nees & Mart.) C.D.Specht & D.W.Stev.), and *C. speciosus* (J.Koenig) Sm. (= *Hellenia speciosa* (J.Koenig) S.R.Dutta). Nevertheless, most of them have been transferred to two other genera, *Chamaecostus* C.D.Specht & D.W.Stev. and *Hellenia* Retz. (Specht and Stevenson 2006; Dutta 2010; Govaerts 2013). Following the publication of the *Flora of Java Volume III*, several botanists have reported additional introduced *Costus* on the island, including *C. afer* (Irsyam et al. 2019), *C. dubius* (Mustaqim and Setiawan 2021), *C. laevis* Ruiz & Pav. (Maas 1979), *C. lucanusianus* J. Braun & K. Schum. (Nisyawati and Mustaqim 2017), and *C. scaber* Ruiz & Pav. (Nisyawati and Mustaqim 2017). Two of them, *C. afer* and *C. dubius*, are naturalized in West Java (Irsyam et al. 2019; Mustaqim and Setiawan 2021).

During our botanical exploration in 2023, we found three additional species of *Costus* in Java: *C. phyllocephalus* K.Schum., *C. spicatus* (Jacq.) Sw., and *C. villosissimus* Jacq. These species have spread outside cultivation and currently grow in the wild without human intervention. Descriptions, photographs, and a brief discussion are provided.



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METHODS

The field study was conducted in Jakarta, West Java, Central Java, and East Java Provinces from January to May 2023 (Figure 1). The plant materials were collected using the standard procedure outlined by Bridson and Foreman in 1998. Subsequently, the specimens were observed at the Herbarium Bandungense (FIPIA), School of Life Sciences and Technology, Institut Teknologi Bandung. In March 2023, additional specimens were examined at the Herbarium Bogoriense (BO; National Research and Innovation Agency (BRIN)). The specimens were identified using the publications of Backer and Bakhuizen van den Brink (1968), Maas (1972, 1975, 1979), Suwandi (1995), Maas and Maas-van de Kamer (1997), Hammel et al. (2003), Chen et al. (2015), Maas-van de Kamer et al. (2016), Skinner (2016), Mustaqim and Nisyawati (2017), Irsyam et al. (2019), Skinner and Liesenfeld (2020), and Mustaqim and Setiawan (2021). The terminology used in the descriptions refers to Beentje (2012).

RESULTS

Costus phyllocephalus K.Schum.

Bot. Jahrb. Syst. 15: 420 (1892)

Figure 1A–D

New records. INDONESIA, JAVA – WEST JAVA • Bogor Regency, Ciomas Subdistrict, Ciapus, Jl. Bojong Sari; 06°35'32.4"S, 106°44'55.5"E; X.2023; DRMG-P-015; FIPIA • Bandung City, Bandung Wetan Subdistrict, Cihapit, Jl. Taman Cibeunying Utara; 06°54'20.3"S, 107°37'29.0"E; IV.2023; ASDI 803; FIPIA – JAKARTA • South Jakarta, Cilandak Subdistrict, Lebak Bulus Village, The Riverville; 06°18'06.5"S, 106°46'19.8"E; II.2023; MFRK 03; FIPIA.

Identification. Rhizomatous herb up to 2 m tall. Rhizomes white to brownish red outside, creamy white inside, internodes 3–12 mm long. Shoots unbranched, spiral, green, glabrous; internodes 2.3–5.8 cm long. Leaves monostichous; sheaths green or with red blotches, up to 2.3 cm wide, glabrous; ligule 2-lobed, 0.9–2.4 cm long, reddish brown; petiole 8–14 mm long; lamina obovate, 15.0–19.3 × 5.8–7.0 cm, base truncate to subcordate, margin undulate, ciliate near the base, apex acuminate to caudate, acumen 14–17 mm long, adaxial surface shiny green, glabrous, abaxial surface glaucous, glabrous. Inflorescence terminal, ovoid, 4.5 cm long. Flowers 1 or 2 per bract; bracts broadly ovate-elliptic, 1.7–2.0 × 1.5–2.5 cm, green, glabrous, bearing leaf-like appendage at the apex; appendage broadly ovate, 1.8–8.5 × 1.9–4.5 cm, green with dark-purple stripes on the abaxial surface, puberulous; bracteoles green, opposite the bract, boat-shaped, 2.0 × 1.2–1.8 cm, glabrous; calyx tubular, green with dark-purple stripes, 1.5–2.0 × 0.8–1.0 cm, 3-lobed, lobes triangulate, 5–6 mm wide, persistent, glabrous; corolla 3-lobed; tube ca. 1.3 cm long, yellowish; lobes white with pinkish stripes, membranous, dorsal lobe elliptical, ca. 4.5 × 1.9 cm, apex acuminate, acumen 1 mm long, lateral lobes narrowly subobovate, 4.5–4.6 × 1.8–2.0 cm; labellum yellowish at base, dark pink at apex, inner side with central yellow nectar guide, funnel-shaped, ca. 7.0 × 5.5 cm, margin undulate; stamen oblong, ca. 4.2 × 1.3 cm, apex yellow, the tip of apex dark pink, fimbriate; anther ca. 8.0 × 5.0 mm, yellowish. Ovary white, 3-loculated, subglobose to ovoid, 8 × 5–6 mm; style filiform, ca. 4.1 cm long, white; stigma flabellate, ca. 3.0 × 4.0 mm, whitish.

Previously known distribution. West Africa (Nigeria), Central Africa (Burundi, Cameroon, the Central African Republic, Congo Brazzaville, Congo Kinshasa, and Gabon), East Africa (Uganda), and southern tropical Africa (Angola, Zambia) (Maas-van de Kamer et al. 2016).

Ecology. *Costus phyllocephalus* can be found at elevations ranging from 0 to 1500 m above sea level in primary or secondary rainforest, gallery forest, and occasionally coastal forest, as well as in wet areas near savannas, rivers, or creeks, or along roads (Maas-van de Kamer et al. 2016). It has been planted in gardens and open areas at altitudes between 30 and 714 m on Java Island. Its adventive population was found at Jl. Bojong Sari, Ciomas Subdistrict, Bogor Regency, in roadside vegetation, abandoned land, and riverside (Figure 2).

Costus spicatus (Jacq.) Sw.

Prodr. Veg. Ind. Occ.: 11 (1788)

Figure 1E–H

New records. INDONESIA, JAVA – WEST JAVA • Bogor Regency, Dramaga Subdistrict, IPB University, Cikabayan Atas Experimental Garden; 06°33'06.1"S, 106°43'04.3"E; II.2023; DRMG-P-008; FIPIA • Department of Agronomy and Agriculture; 06°33'32.3"S, 106°43'46.9"E; II.2023; DRMG-P-009; FIPIA • the Arboretum behind the Al Hurriyyah Mosque, FIPIA; 06°33'14.9"S, 106°43'29.5"E; III.2023; DRMG-P-010; FIPIA • Perumanan Dosen IPB; 06°33'09.6"S, 106°43'15.4"E; III.2023; DRMG-P-011; FIPIA.

Identification. Rhizomatous herb up to 1.5 m tall. Rhizomes creamy white to reddish on the outside, creamy white inside, internodes 5–30 mm long. Bulbils growing at nodes, ovoid, 7–20 mm long, with reddish scales. Shoots unbranched, spiral, green, glabrous; internodes 2.0–4.2 cm long. Leaves monostichous; sheaths green, up to 7 cm wide, puberulous; ligule 2-lobed, 5–10 mm long, reddish, with fibrous hairs at the

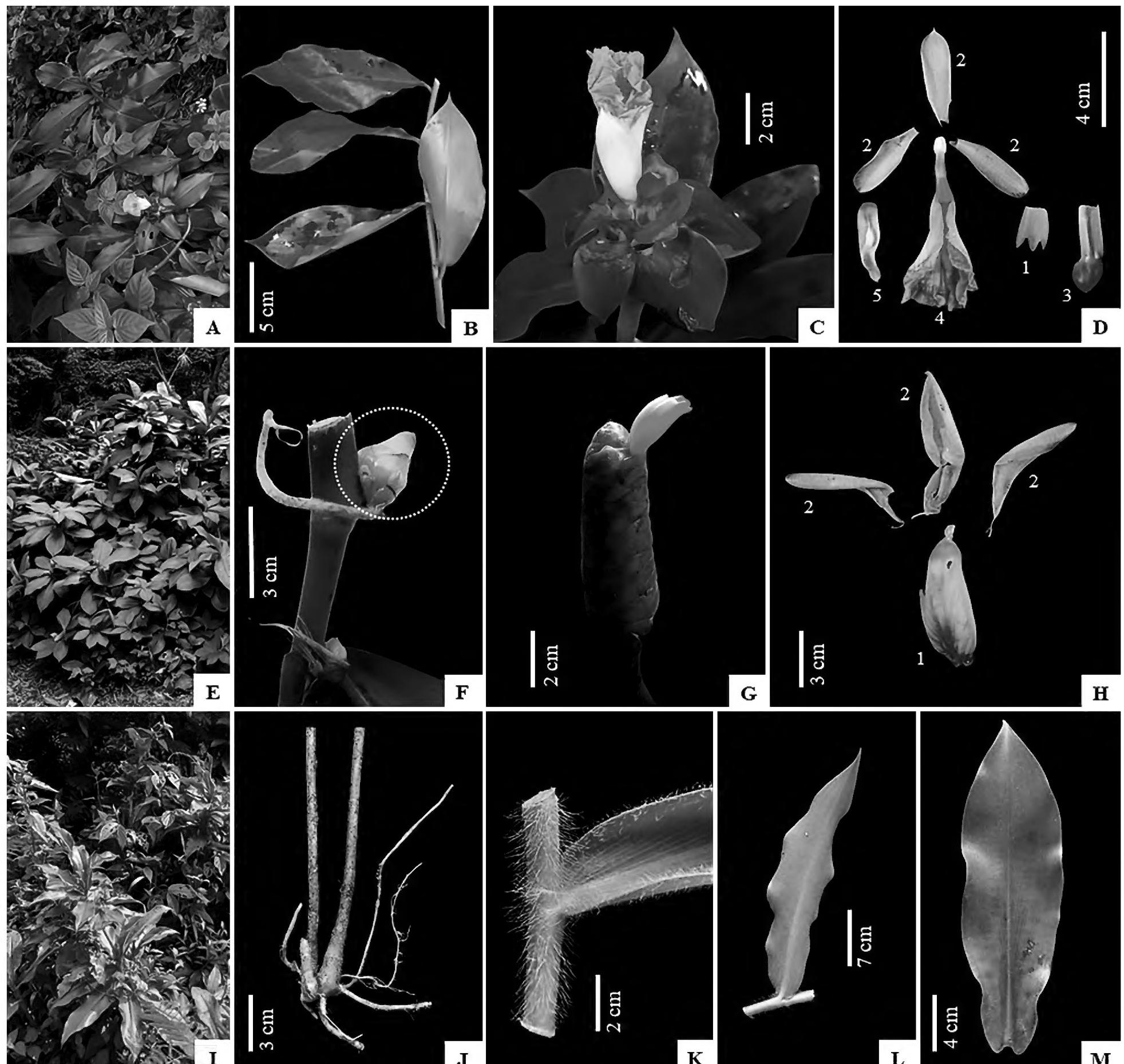


Figure 1. Three newly reported *Costus* species in Java. **A–D.** *C. phyllocephalus*: (A) naturalized population, (B) leafy shoot, (C) terminal inflorescence showing a flower in bloom, (D) flower parts consisted of calyx, corolla, ovary, labellum, and fertile stamen numbered 1–5, respectively. **E–H.** *C. spicatus*: (E) naturalized population, (F) leafy shoot with axillary flower bud, (G) inflorescence showing an unopened flower, (H) flower parts consisted of labellum and corolla numbered 1 and 2, respectively. **I–M.** *C. villosissimus*: (I) naturalized population, (J) leafy shoot with clumped rhizome, (K) hairs on internode and leaf, (L) abaxial view of leaf, (M) adaxial view of leaf.

apex; petiole 10–15 mm long, tomentose; lamina broadly obovate or elliptic, $7.5–35.0 \times 4.2–17.5$ cm, base truncate, margin entire, ciliate, apex acuminate, acumen short, 5–9 mm long, adaxial surface green, with dark-green stripes, glabrous, abaxial surface glaucous, shiny, puberulous. Flowers 1 per bract; bracts 5–10 mm long broadly ovate, margins of the covered part dilacerating into fibers, apex obtuse, greenish or reddish in the exposed part, reddish in the covered part, coriaceous, callus yellow, glabrous; bracteoles 15–25 mm long, puberulous to glabrous; calyx 8–15 mm long, puberulous to glabrous, lobes shallowly triangular, 2–3 mm long; corolla yellow to pink, 35–45 mm long, glabrous, tube up to 10 mm long, lobes narrowly obovate, $27–35 \times 8–15$ mm; labellum yellow, oblong-obovate, 25×45 mm, lateral lobes rolled inwards forming a slender tube, margins crenulate; stamen narrowly elliptic, $30–40 \times 10$ mm, rounded or obtuse at the apex; anther ca. 7–8 mm long, yellow. Ovary white, 4–9 mm long, sericeous; style filiform, white, ca. 3 cm long, white; stigma flabellate, ca. 3.0×4.0 mm, white.

Previously known distribution. The species is naturally distributed in Cuba, Dominican Republic, Haiti, Leeward Islands, Gulf of Mexico, Mexico (north and southeast), Puerto Rico, and Windward Islands (POWO 2024).

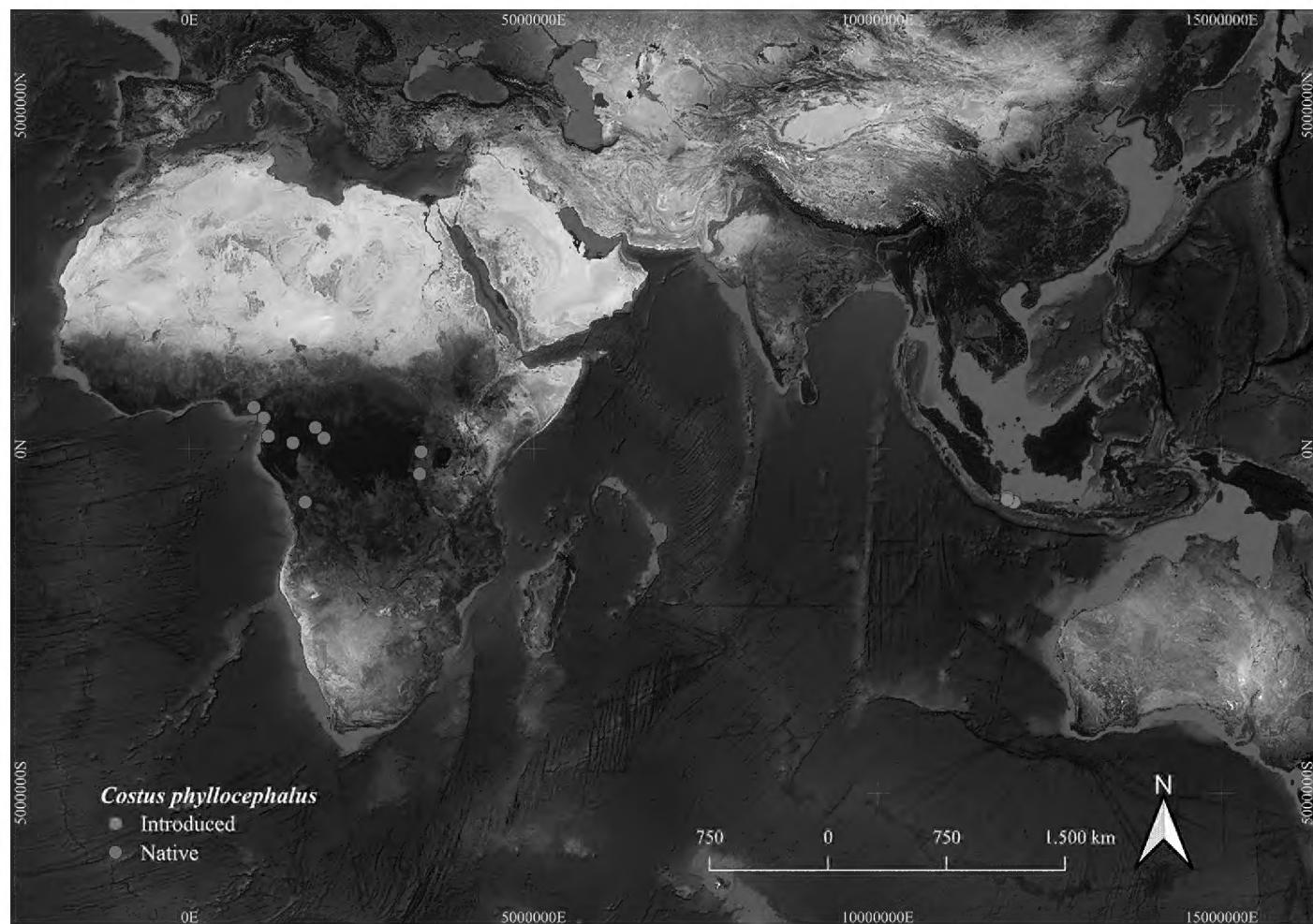


Figure 2. The native range (green dots) and naturalized location (purple dot) of *Costus phyllocephalus* in Java.

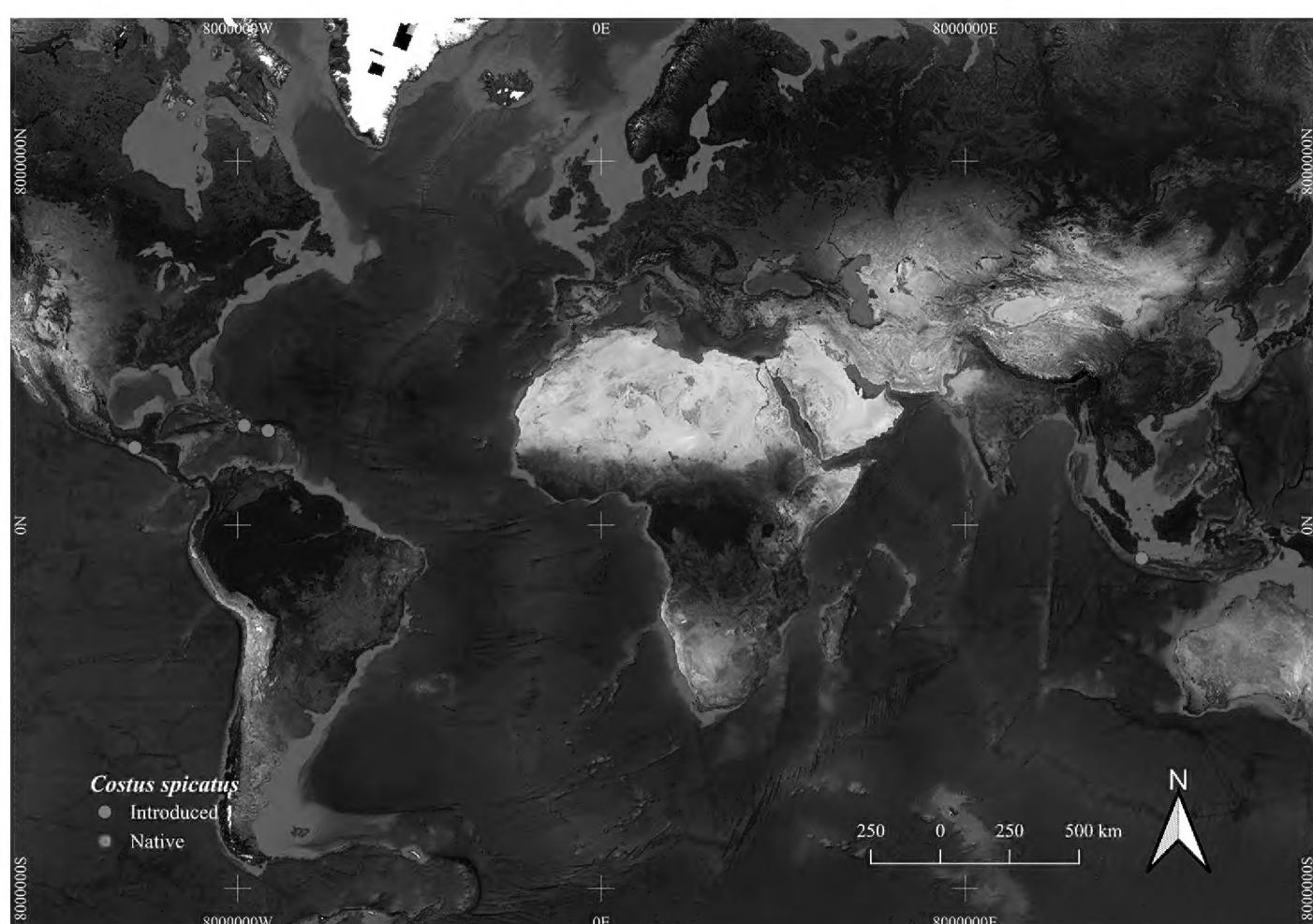


Figure 3. The native range (red dots) and naturalized location (cyan dot) of *Costus spicatus* in Java.

Ecology. The species grows in humid environments at elevations ranging from 0 to 50 m above sea level, within its natural distribution range (Hammel et al. 2003). *Costus spicatus* thrives in humid and shaded environments at elevations of 183 to 187 m in West Java (Figure 3).

***Costus villosissimus* Jacq.**, Fragm. Bot.: 55 (1806)
Figure 1l–M

New records. INDONESIA, JAVA – WEST JAVA • Bogor Regency, Tenjolaya Subdistrict, Gunung Malang Village, Jl. Hegarmanah, 06°39'41.1"S, 106°43'21.4"E; III.2023; ZA230376; FIPIA.

Identification. Rhizomatous herb up to 1.5 m tall. Rhizomes creamy white to yellowish on outside, creamy white inside, internodes 4–8 mm long. Shoots unbranched, spiral, green, villous, indumentum brownish to golden brown; internodes 2.0–3.3 cm long. Leaves monostichous; sheaths green, up to 4.7 cm wide, ferruginous-pilose; ligule truncate to mucronate, ca. 4 mm long, green; petiole 5 mm long, villous to ferruginous-pilose; lamina obovate to broadly lanceolate, 22.0–25.7 × 6.1–7.5 cm, base broadly cuneate to very

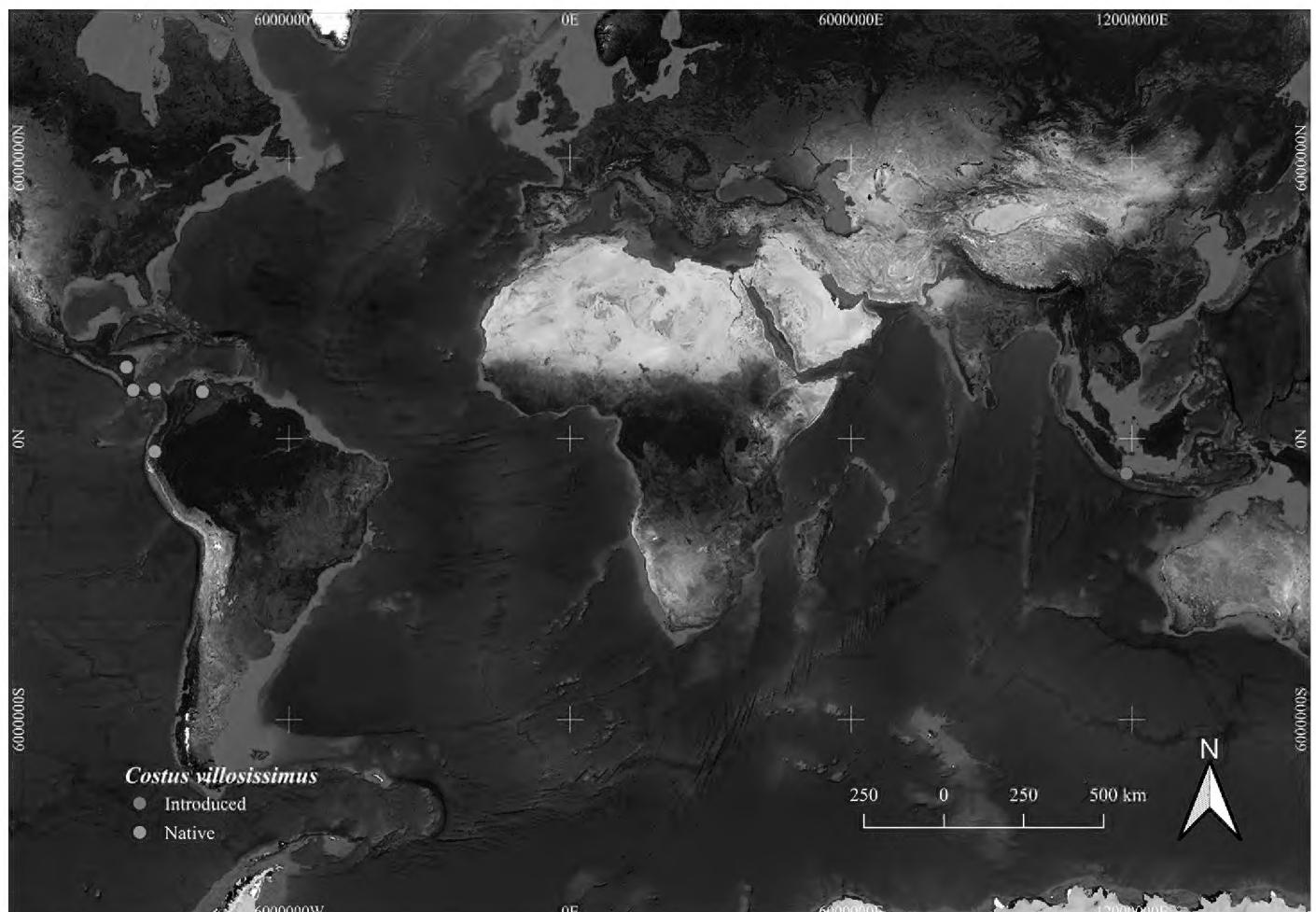


Figure 4. The native range (lavender dots) and naturalized location (lime dot) of *Costus villosissimus* in Java.

obscurely auriculate-subcordate, margin undulate, ciliate, apex shortly acuminate to caudate, adaxial and abaxial surface green, ferruginous-pilose, particularly in margin and midrib.

Previously known distribution. *Costus villosissimus* is naturally distributed in northwestern South America, Central America (mostly confined to Panama), Jamaica, and St. Vincent (Maas 1972).

Ecology. The species can be found in riverbank woods, foothill forests, lowland thickets, and swamps from sea level to 1100 m (Maas 1972). In our study, it was discovered in an open area at 600 m above sea level in Gunung Malang village, Tenjolaya, Bogor Regency (Figure 4).

Note. During the field research, the generative organs were not discovered. However, Maas (1972: 50) described the generative parts: “inflorescence ovoid, 6–10 cm long, 3.5–6.5 cm diameter. Bracts coriaceous, green or red, broadly ovate, 2–4(–6) cm long, 2.5–3.5(–4) cm wide, callus absent or to 6 mm long. Bracteole 17–30 mm long, glabrous, or nearly so. Calyx 8–16 mm long, glabrous to sparsely puberulous, lobes deltate, 4–6 mm long. Corolla yellow (rarely white), 60–80 mm long, glabrous, tube 10–20 mm, lobes narrowly obovate, 50–60 mm long, 20–30 mm wide. Labellum yellow (rarely white), broadly obovate when spread out, 70–90 mm long, ca. 60 mm wide, margins glabrous or fimbriate, middle lobe reflexed. Stamen yellow, ca. 50 mm long to 15 mm wide, apex irregularly lobed, anther 9–10 mm long”.

DISCUSSION

Previous research revealed that two introduced *Costus* species, *C. afer* and *C. dubius*, had naturalized in West Java (Irsyam et al. 2019; Mustaqim and Setiawan 2021). In this study, we report the presence of spontaneous populations of *C. phyllocephalus*, *C. spicatus*, and *C. villosissimus* from the same province. These species are newly reported alien species in Java.

Costus spicatus can be found growing spontaneously in rubber plantations, along roads, and in abandoned areas in the Dramaga Subdistrict of Bogor. The initial record of this occurrence was found in an unpublished report detailing a botanical expedition on 16 February 2015. Nine years ago, the first spontaneous population of *C. spicatus* was discovered in the arboretum area at IPB University, specifically behind the Al Hurriyyah Mosque. At present, the wild population of *C. spicatus* has undergone a significant expansion on the Darmaga Campus of IPB University. The species propagates itself by rhizomes and axillary bulbils. The bulbils can be easily detached from the parent plants, either through the actions of animals or through the plants' own mechanisms. According to an assessment by USDA-ARS (2014), human activities have been identified as the main factor responsible for the spread of this species to new areas. The main mechanism of distribution in West Java is thought to be vegetative fragments in waste soil. The rhizomes exhibit strong resilience and pose a formidable challenge to eliminate once they have taken root.

Costus phyllocephalus is a fascinating ornamental species that originates from tropical Africa (Maas-van de Kamer et al. 2016). The labellum of this species is the largest compared to other species, measuring up to 5.5 cm wide. In Ciomas Subdistrict, Bogor Regency, the plant has grown spontaneously along roadsides

and abandoned sites. Some individuals have also been observed growing along rivers, indicating that water may disperse rhizome fragments or bulbs to new locations. *Costus phyllocephalus* is often mistaken for *C. afer* due to its pink labellum. Alternatively, *C. phyllocephalus* exhibits elongate ligules and bracts that have a wide, ovate appendage at their tip, which distinguishes it from *C. afer*. Additionally, in our field study, we also collected two specimens from cultivated individuals located in South Jakarta and Bandung.

Costus villosissimus has recently been found in the Tenjolaya Subdistrict of Bogor Regency. This species has shown remarkable resilience, as it has only been found at a one location. Despite our extensive observations, we have not come across it in any other plants in nearby natural habitats. *Costus villosissimus* is easily recognized due to the presence of long, brownish, villose hairs that cover the entire plant. The wild population likely escaped from nearby inns or villas that cultivate ornamental plants. The spontaneous populations flourish on a steep incline beside the road in areas with a mix of shade and sunlight, and on moist soil at an elevation of 600 m.

These three species have the possibility of expanding their distribution in the future. Thus, further study is required to ascertain their potential for invasiveness in Java. In addition, there may be other species in Java which have gone unreported, and further studies on the diversity of *Costus* in Java are still necessary.

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ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests.

Ethical statement

No ethical statement is reported.

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Author contributions

Conceptualization: ASDI, MRH. Data curation: ASDI, MRH, ZAA, APD, MHF, MHB. Formal analysis: ASDI, MRH, P. Investigation: ASDI, MRH, MHF, ZAA, MFRK, MHB. Methodology: ASDI, MRH. Visualization: MRH, P. Supervision: DR. Validation: ASDI. Writing – original draft: MRH, ASDI, ZAA, MHF, MHB. Writing – review and editing: ASDI, MRH, MHF, APD, ZAA, DR.

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Data availability

All data that support the findings of this study are available in the main text.

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